MEMORANDUM

State of Alaska

Department of Fish and Game
Division of Sport Fish

TO: Distribution

DATE: February 6, 2013

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SUBJECT: Outlook for the 2013 Kenai River Chinook salmon Late Run

The outlook for the late run of Kenai River Chinook salmon in 2013 is well below average, with a forecast total run of approximately 29,000 fish. If realized, this run would rank 27th out of 28 years, be similar in abundance to the runs of 2009–2012, and would be approximately one-half the 1986–2012 average run of approximately 58,000 fish. Using the same methodology to forecast the 2013 total run, forecasts were made for the previous 5 years (2008–2012). Errors in the hindcasts of the total run forecasts were small, ranging from less than 1% to 10% (Figure 1). If the 2013 forecast is realized, the 2013 run, without harvest, will be below the upper end of the recommended sustainable escapement goal (SEG) of 15,000 to 30,000 fish.

The forecast of total run is calculated from the sum of selected individual forecasts of abundance for fish ages 3 to 7. Forecast abundance for each age class (Table 1) was calculated from several models based on relationships between adult returns, spawners, or siblings from previous years, including simple linear regression, recent year means and medians, time series, and combinations thereof (Table 2). The model estimates selected for each age class for inclusion in the 2013 forecast were those having the greatest recent accuracy and precision. Accuracy and precision were estimated by mean absolute deviation (MAD), mean absolute percent error (MAPE), mean percent error (MPE), and 3yr-MAPE between hindcasts of previous years' forecasts and actual runs (years 2008 through 2012).

For age-3 fish, the Univariate Log AR1 model forecast estimate was selected (a run of 759 fish; lowest MAD and MPE and the second lowest MAPE). Fewer models can be used to forecast abundance for this age class because there are no prior sibling returns to provide insights and raw data.

For age-4 fish, the median, and most recent sibling models had equally low MPE and had the lowest MAD; therefore the mean of both forecasts was selected (a run of 4,001 fish).

Two models also performed similarly for the forecast of age-5 fish abundance; the most recent sibling, and the recent 5-year mean sibling. Each model had the lowest MPE. The most recent sibling model also had the lowest MAPE and MAD. The recent 5-year mean sibling model had the second lowest MAPE, third lowest 3-yr MAPE, and fourth lowest MAD. The average of the two models forecast a run of 2,886 age-5 fish. This is significantly lower than the estimated recent 5-year average actual run size of 8,961 age-5 fish, and is considered the most questionable age class forecast.

Age-6 fish are generally the predominant age class for late run Kenai River Chinook salmon. The most recent sibling model (using age-5's) and the most recent sibling model (using age-5's and age-4's) had the lowest and second lowest MPE for age-6 fish. Those models were averaged to forecast a run of 20,453 age-6 fish.

For age-7 fish, the mean sibling model had the least amount of error for all four types (MAD, MAPE, MPE, and 3-yr MAPE), and forecast a run of 920 fish in 2013.

In addition to the forecasting methods used above, a modified version of the state-space model used in the escapement goal analysis for 2013 (Fleischman and McKinley *in preparation*) was constructed to provide a forecast of run size and age composition. According to this forecast, the 2013 total run is equally likely to be above or below approximately 24,000, and there is a 95% probability that the run will be between approximately 17,000 and 35,000 Chinook salmon. Hindcasts of run forecasts tracked well with actual run size for the years 2008–2012, although hindcasts were consistently higher by 5% to 30% (Figure 1).

Whereas the base model of Fleischman and McKinley (*in preparation*) assumed constant age at maturity, the modified model allowed age at maturity to vary across brood years. Age at maturity for a given brood year was allowed to vary randomly from the proportions predicted by the trend. The forecast for 2013 was generated by running the modified model forward an additional year beyond the last year of data (2012). The forecast synthesizes information about the Ricker relationship, time-specific productivity, and varying age at maturity. The total run forecast is the sum of individual forecasts for the five age classes (ages 3, 4, 5, 6, and 7). Prediction intervals and probability statements can be constructed using percentiles from Table 3. For example there is an 80% probability that the 2013 will be between approximately 19,000 and approximately 31,000; and there is 95% probability that fewer than approximately 33,000 Kenai River late-run Chinook salmon will return in 2013.

Table 1.–Chinook salmon forecasts for the 2103 Kenai River Late Run using several models, and the fit of each model to the previous 3 or 5 years of actual returns. Boxes around values indicate those with the lowest associated error and hence were selected to compose the total run forecast. Shaded boxes indicate the selected forecast for each age class. See Table 2 for a description of each model.

	Forecast	5-Year			3-Year
Model	**2013**	**MAD[a]**	**MAPE[b]**	**MPE[c]**	**MAPE**
	Age-3				
5-year mean	1,341	569	0.55	-0.34	0.79
Univariate Log AR1	**759**	646	0.48	**-0.03**	0.61
Mean	857	654	0.45	0.23	0.48
Median	572	801	0.50	0.47	0.45
Forecast estimate	**759**				
	Age-4				
5-year mean	7,620	5,686	1.31	-1.31	1.13
Univariate AR1	6,643	5,435	1.06	-0.76	1.09
Standard Sibling	7,007	5,556	1.04	-1.04	1.39
Standard Log Sibling	5,773	4,108	0.73	-0.72	1.06
Standard Ricker	6,398	4,046	0.76	-0.49	0.79
Mean	8,972	3,898	0.81	-0.62	0.91
Median	**6,524**	3,738	0.60	**-0.23**	0.66
Mean sibling	9,845	18,500	2.89	-2.89	3.70
Median sibling	6,430	9,504	1.53	-1.53	2.06
Most recent sibling	**1,479**	1,945	0.34	**-0.23**	0.47
Recent 5-year mean sibling	3,185	7,230	1.02	-1.02	1.26
Forecast estimate	**4,001**				
	Age-5				
5-year mean	8,961	5,292	0.85	-0.79	0.24
Univariate Log AR1	12,001	3,795	0.60	-0.45	0.31
Standard Sibling	7,983	4,072	0.55	-0.55	0.33
Sibling 1987 on	7,741	3,657	0.50	-0.50	0.29
Log Sibling 1987 on	7,876	2,585	0.39	-0.39	0.17
Log Sibling 1987 on AR1	7,639	2,062	0.33	-0.25	0.07
Sibling AR1,2 1987 on	6,411	1,744	0.25	-0.20	0.06
Sibling AR1,2	6,690	1,630	0.24	-0.21	0.04
Standard Ricker	12,863	3,083	0.45	-0.22	0.24
Mean	12,871	4,380	0.71	-0.71	0.38
Median	10,955	2,533	0.46	-0.43	0.20
Mean sibling	4,881	8,634	0.93	-0.93	0.76
Median sibling	3,889	5,773	0.62	-0.62	0.48
Most recent sibling	**3,026**	1,371	0.17	**0.03**	0.18
Recent 5-year mean sibling	**2,745**	2,017	0.20	**-0.03**	0.18
Forecast estimate	**2,886**				

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Model	Forecast 2013	5-Year MAD[a]	5-Year MAPE[b]	5-Year MPE[c]	3-Year MAPE
	Age-6				
5-year mean	17,386	14,056	0.98	-0.98	1.12
Univariate Log AR1	16,375	8,444	0.66	-0.60	0.82
Standard Sibling	31,524	14,285	0.99	-0.99	1.28
Sibling AR1	23,041	7,725	0.50	-0.50	0.57
Standard Log Sibling	29,001	13,197	0.94	-0.94	1.22
Log Sibling AR1	16,916	5,615	0.40	-0.36	0.44
Sibling 2000 on	25,793	6,783	0.39	-0.39	0.38
Sibling 1995 on	27,583	9,188	0.60	-0.60	0.70
Sibling 1987 on	31,778	14,045	0.96	-0.96	1.21
Log Sibling 2000 on	22,842	7,410	0.49	-0.49	0.56
Log Sib 1995 on	25,218	9,290	0.65	-0.65	0.80
Log Sib 1987 on	29,238	13,077	0.92	-0.92	1.17
Sibling 2000 on AR1	22,193	3,939	0.22	-0.14	0.20
Sibling 1995 on AR1	22,393	5,531	0.33	-0.33	0.34
Sibling 1987 on AR1	21,546	5,700	0.36	-0.36	0.38
Log Sibling 2000 on AR1	16,573	3,105	0.21	-0.11	0.22
Log Sibling 1995 on AR1	17,040	4,653	0.33	-0.27	0.35
Log Sibling 1987 on AR1	16,633	5,133	0.37	-0.30	0.40
Standard Ricker	33,279	12,443	0.87	-0.87	1.05
Ricker AR1	18,947	7,026	0.54	-0.51	0.68
Mean	33,053	17,995	1.33	-1.33	1.82
Median	30,982	14,593	1.12	-1.12	1.59
Mean sibling	34,294	13,484	0.75	-0.75	0.72
Median sibling	27,268	8,007	0.41	-0.41	0.33
Most recent sibling (5's and 4's)	**20,966**	5,395	0.32	**-0.08**	0.40
Most recent sibling	**19,939**	3,459	0.22	**-0.07**	0.28
Recent 5-year mean sibling	20,978	3,836	0.20	-0.15	0.17
Recent 5-year mean sibling (5's and 4's)	19,362	6,767	0.32	-0.24	0.19
Forecast estimate	**20,453**				
	Age-7				
5-year mean	1,610	1,702	1.63	-1.59	2.11
Standard Sibling	1,020	609	0.33	-0.12	0.12
Standard Log Sibling	827	699	0.31	0.19	0.21
Standard Ricker	1,849	2,512	2.08	-1.97	2.73
Ricker AR1	1,428	2,097	1.63	-1.63	1.54
Mean	2,570	1,386	1.31	-1.24	1.76
Median	1,709	985	0.82	-0.67	0.99
Mean sibling	**920**	599	0.28	**-0.01**	0.07
Median sibling	882	648	0.29	0.11	0.12
Most recent sibling	888	933	0.65	-0.39	0.23
Recent 5-year mean sibling	1,065	874	0.53	-0.31	0.33
Forecast estimate	**920**				
TOTAL RUN FORECAST	**29,019**				

[a]mean absolute deviation

[b]mean absolute percent error

[c]mean percent error

Table 2.–Description of models used in forecasting the Kenai River Chinook salmon late run, 2013.

Model	Description
5-year mean	Mean of the 2008-2012 run for the specified age class.
Univariate Log AR1	Autoregressive of order 1 time series model using natural log of all years of returns (1983-2006 brood years).
Standard Sibling	Sibling regression using all years of returns (1983-2006 brood years).
Sibling AR1	Sibling regression using all returns (1983-2006 brood years) and a lag 1 autoregressive term.
Standard Log Sibling	Sibling regression using natural log of all years of returns (1983-2006 brood years).
Log Sibling AR1	Sibling regression using natural log of all returns (1983-2006 brood years) and a lag 1 autoregressive term.
Sibling AR 1,2 1987 on	Sibling regression using brood years from (1987-2006) and a lag 1 and lag 2 autoregressive term.
Sibling AR 1,2	Sibling regression using all returns (1983-2006 brood years) and a lag 1 and lag 2 autoregressive term.
Sibling XXXX (year) on	Sibling regression using returns. Exact year (XXXX) to begin data set depends upon age class being modeled, through 2006 brood year.
Log Sibling XXXX (year) on	Sibling regression using natural log of returns. Exact year (XXXX) to begin data set depends upon age class being modeled, through 2006 brood year.
Sibling XXXX (year) on AR1	Sibling regression using returns and a lag 1 autoregressive term. Exact year (XXXX) to begin data set depends upon age class being modeled, through 2006 brood year.
Log Sibling XXXX (year) on AR1	Sibling regression using natural log of returns and a lag 1 autoregressive term. Exact year (XXXX) to begin data set depends upon age class being modeled, through 2006 brood year.
Standard Ricker	Ricker-style regression using all brood years (1983-2006).
Ricker AR1	Ricker-style regression using all brood years (1983-2006) and a lag 1 autoregressive term.
Mean	Mean using all brood years (1983-2006).
Median	Median return of all brood years (1983-2006).
Mean sibling	Mean of sibling ratios (age/age minus 1) for all returns (1983-2006 brood years) multiplied by the return of age minus 1 siblings.
Median sibling	Median of sibling ratios (age age minus 1) for all returns (1983-2006 brood years) multiplied by return of age minus 1 siblings.
Most recent, relative to mean sib (5's and 4's) (to forecast age-6 fish)	Most recent ratio of (age-6)/(age-5+ age-4), multiplied by the return of age-5 and age-4 siblings.
Most recent sibling	Most recent sibling ratio (age/age minus 1), multiplied by the return of age minus 1 siblings.
Recent 5-year mean sibling	Mean of sibling ratios (age/age minus 1) for previous 5 brood years multiplied by the return of age minus 1 siblings.
Recent 5-year mean sibling (5's and 4's) (To forecast age-6 fish)	Mean of sibling ratios (age/ age minus 1+ age minus 2) for previous 5 brood years multiplied by return of age-5 and age-4 siblings.

Table 3. Posterior percentiles of forecasted total run for late-run Kenai River Chinook salmon in 2013 using a state-space model analysis.

Posterior mean	Posterior SD	Posterior Percentiles								
		0.025	0.05	0.10	0.25	0.50	0.75	0.90	0.95	0.975
24,270	4,769	16,870	17,750	18,840	20,870	23,560	27,010	30,730	33,110	35,270

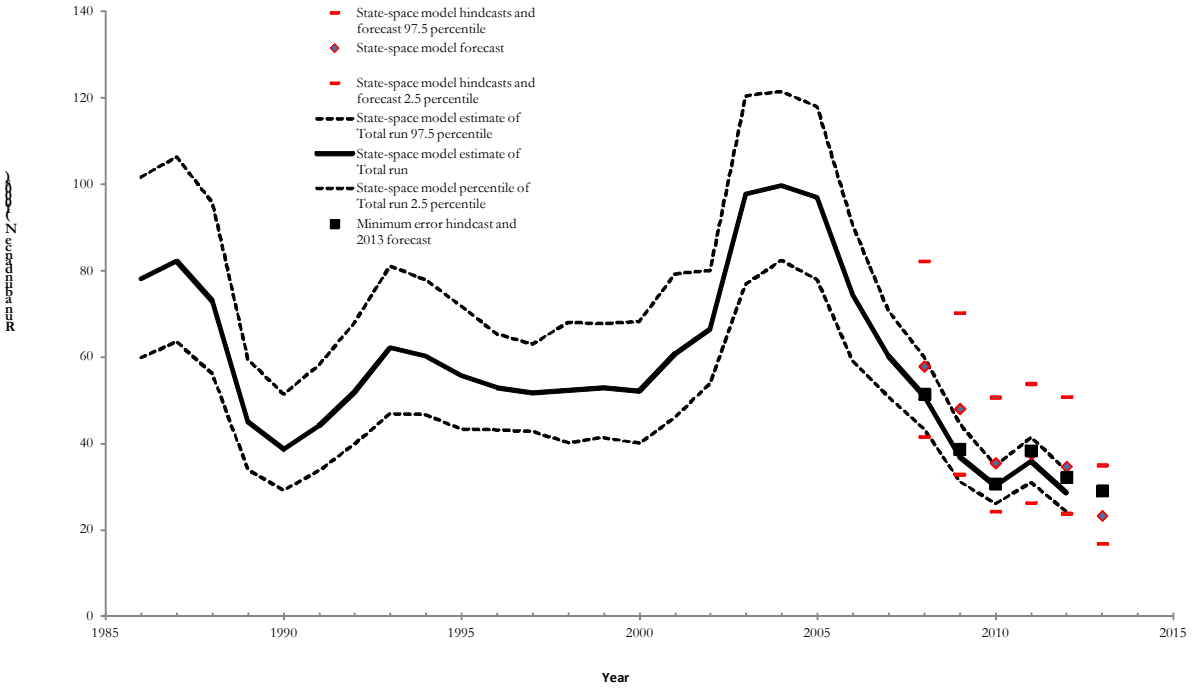

Figure 1.–Hindcasts (2008 - 2012) and forecasts (2013) of total run compared to estimated total run for Kenai River late-run Chinook salmon.

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